RESEARCH PLAN for Ph.D. Degree

SYNTHESIS OF CARBON NANOTUBE FROM NATURAL SOURCES AND IT'S APPLICATION AS DOPANT TO INCREASE POLYMER CONDUCTIVITY

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NANOTECHNOLOY

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SYNOPSIS

1. Introduction and Origin of research problem

Nanotechnology is defined as technology where dimensions and tolerances are in the range of 0.1-100 nm (from size of the atom to about the wavelength of light) play a critical role. Nano technology relates to the ability to build functional devices based on the controlled assembly of nano scale objects for specific technological applications. One nanometer is a magical point on the dimensional scale. There is a sudden shift of all properties of material when they just enter into the nanoscale.

A significant nanotechnology discovery that came to light in 1991 was carbon nanotubes. Carbon nanotubes (CNTs) are allotropes of carbon with a cylindrical nanostructure. Nanotubes have been constructed with length-to-diameter ratio of up to 132,000,000:1. Carbon nanotubes are cylindrical structures that have diameters as small as 1 nm and lengths up to several centimeters. Carbon nanotubes have the highest strength-to-weight ratio of any known material. Although carbon nanotubes are strong, they are not brittle. They can be bent, and when released, they will spring back to their original shape.

Carbon nanotubes can occur as multiple concentric cylinders of carbon atoms, called multi-walled carbon nanotubes (MWCTs). Logically enough, carbon nanotubes that have only one cylinder are called single-walled carbon nanotubes (SWCTs). Both MWCT and SWCT are used to strengthen composite materials

CNTs formed from Chemicals usually don't have connecting sites. They need to be functionalized for further applications. CNTs from natural resources are mostly functionalized. They do have connecting sites which helps them to get attached to other polymers and chemicals, which give it a wide range of applications. [1, 2]

There are two standard types of SWNTs constructions from a single grapheme sheet according to integers (n,m). The (n,0) structure is called ''zigzag'' and the structure where n ¼ m (n,n) is called ''armchair''.
The third non-standard type of CNTs construction, which can be characterized by the equation where $n > m > 0$, is called ''chiral''. The chirality predestinates the electrical, mechanical, optical and other properties of CNTs. Dresselhaus et al. reported how the chiral vector and the corresponding pairs of integers influence the electrical properties of CNTs.[3,4]

Carbon nanotubes (CNTs) have shown significant potential; they can be used in a wide variety of applications on the basis of their remarkable mechanical and electronic properties [5-9]. CNTs have highly π-conjunctive and hydrophobic sidewalls consisting of sp^2 carbons [10], which enable them to be incorporated into organic solar cells. Recently, there has been a large interest

in incorporating carbon nanotubes (CNTs) into organic solar cells because of their unique electrical properties of CNTs. For example, CNTs were used as electron acceptors in the photoactive layer of the solar cells [11]. Also, CNTs were used as transparent anodes in order to replace the prevailing and widely used indium tin oxide (ITO).

2. Objectives

The prime objective is to synthesize some novel CNTs particularly functionalized and use them as dopant in polymer electrolyte for further application in dye sensitized solar cell (DSSC).

This can be achieved by :

Synthesis of CNTs

CNTs will be synthesized from natural sources (argemone mexicana, natural milk,neem oil, karanja oil , egg protein etc.) via different methods such as spray pyrolysis, chemical vapor deposition, green method. Their detailed characterization will be carried out.

Doping of CNTs in polymer electrolytes

The CNTs so formed will be doped in polymer electrolyte for further improvement . the conductivity of this electrolyte is expected to be high.

Good efficient DSSC shall be fabricated using above modified polymer electrolyte. The device shall be characterized for their optimum value.

3. Status of Recent Research at national level related to the problem

In India, the studies have just been started for their possible use in DSSC.

Out of all CNTs synthesized so far were mainly concentrated on chemical sources and very few groups in India have worked on CNTs application in DSSC. Several groups in India are working on Polymer-CNT electrolyte such as Indian Institute of Technology-Kahargpur; National Chemical lab, Pune; Centre for Research in Nanotechnology & Science, Indian Institute of Technology-Bombay. [12-15]

4. Status of Recent Research at international level related to the problem

Internationally, Prof. Shaker Ebrahim's group of Egypt, The Agency for Science, Technology and Research (A*STAR) of Singapore and researchers from other countries have also taken up the lead to explore the various physicochemical properties and possible application of Polymer-CNT Composite.[16-17]

5. Detailed Methodology/ Testing of hypothesis

We do have many methods to synthesize Carbon nanotubes. The methods we will be using are green method and spray pyrolysis method. Using this method one can synthesize CNTS with functional sites (mostly). One of the novel method to develop a Polymer-CNT Electrolyte film is solution cast method.

The approach in present work shall be:

a) Synthesis of CNT

Natural sources will be chosen as carbon source for CNTs and nickel and cobalt as catalyst. The possible reason behind the variation will also be searched. CNTS will be synthesized by green method. The Carbon source will be mixed with metal salts in aqueous medium. The solution will be kept in desiccators for Complexation. The complex will be then decomposed in muffle furnace at & 700° C-800° C. The CNTs so formed will be kept in HCL solution for 12 hrs so that the unreacted metal salts will get dissolved in HCL. The solution will be centrifuged and the filtrate will be dried in oven at 50-55° C. The Purified CNT will be obtained. The CNT so obtained will be further characterized using various techniques.

b) CNT Doping

Polymer will be chosen as host polymer and CNT so synthesized will be added to the polymer. The film will be prepared by the standard solution cast technique. Polymer and CNT so obtained will be weighed separately in desired amount and then dissolved in methanol or any other organic solvent. The solution will be stirred long time for uniform mixing and complexation. Then the mix viscous Polymer-CNT will be poured in polypropylene/Teflon moulds for casting in room ambient. The solvent will be slowly evaporated at room temperature and a free standing Polymer-CNT film will be obtained. The thermal, structural and electrical properties will be studied.

6. Expected Outcomes

The favorable results from this research will lead to the following impacts:

i. The in-depth understanding of functionalized CNTs and electrical properties of polymer-CNTS electrolyte. This will help development of novel membrane materials and/or improvements of the performance of current materials for possible application

ii. The understanding about the possible application of this nano-composite shall not be only cheaper but also nature friendly.

iii. The novel CNTs synthesized can also be used in medical field for drug delivery as well as for hydrogen storage.

7. **List name of 05 Journals related to the topic** (National and International)

1. International Journal of Photoenergy
2. Applied Physics letters
3. Carbon Letters
4. International Journal of Electrochemical Science
5. Nanoscale Research Letters

References:

1. Tiwari, IP Tripathi, Sanjay Saxena (2011), *Synthesis characterization and study of properties of CNTs prepared by egg protein and metal salt.* Indian Journal of Applied research 3(2)
2. Tiwari B, Tripathi IP, Saxena S (2012*), Synthesis of carbon nanotubes using spinach, characterization and study of magnetic propertie's* , J Indian Chem Soc 89,1143–1148
3. M. S. Dresselhaus, G. Dresselhaus and R. Saito(1995), *PHYSICS OF CARBON NANOTUBES* , Carbon, 883–891.
4. Wei-xue LI, Yuan HAO, Yong-fu CUI, Jian-feng DAI, Ti-jun CHEN,Qing WANG, Zhong-li WU, Yang LI (2007) *Magnetic properties of multi-walled carbon nanotubes encapsulated Fe/Co particles.* J Trans Non Ferrous Metal Soc China 17,696–699
5. H. Dai, J. H. Hafner, A. G. Rinzler, D. T. Colbert, and R. E. Smalley(1996),*Nanotubes as nanoprobes in scanning probe microscopy,* Nature, vol. 384, no. 6605, pp. 147–150
6. W. B. Choi, D. S. Chung, J. H. Kang et al.,(1999) *Fully sealed, high-brightness carbon-nanotube field-emission display,*Applied Physics Letters, vol. 75, no. 20, pp. 3129–3131.
7. C. Liu, Y. Y. Fan, M. Liu, H. T. Cong, H. M. Cheng, and M. S. Dresselhaus, (1999) *Hydrogen storage in single-walled carbon nanotubes at room temperature*, Science, vol. 286, no. 5442, pp. 1127–1129.
8. P. J. de Pablo, E. Graugnard, B. Walsh, R. P. Andres, S. Datta, and R. Reifenberger, (1999) *A simple, reliable technique for making electrical contact to multiwalled carbon nanotubes,* Applied Physics Letters, vol. 74, pp. 323–325,
9. Y. Y. Wei and G. Eres, (2000) *Directed assembly of carbon nanotube electronic circuits," Applied Physics Letters,* vol. 76, no. 25, pp. 3759–3761.

10. T. Abdel-Fattah, E. J. Siochi, and R. E. Crooks,(2006) *Pyrolytic synthesis of carbon nanotubes from sucrose on a mesoporous silicate,* Fullerenes Nanotubes and Carbon Nanostructures, vol. 14, no. 4, pp. 585–594,.

11. S. Berson, R. De Bettignies, S. Bailly, S. Guillerez, and B. Jousselme (2007)*"Elaboration of P3HT/CNT/PCBM composites for organic photovoltaic cells,"* Advanced Functional Materials, vol. 17, no. 16, pp. 3363–3370,

12. S. Maiti, S. Suin, N. K. Shrivastava and B. B. Khatua (2013) *Low percolation threshold in polycarbonate/multiwalled carbon nanotubes nanocomposites through melt blending with poly(butylene terephthalate)*, Journal of Applied Polymer Science, 130, 543-553

13. S. Maiti, N. K. Shrivastava, S. Suin and B. B. Khatua (2013) *Polystyrene/MWCNT/graphite nanoplate nanocomposites: Efficient electromagnetic interference shielding material through graphite nanoplate-MWCNT-graphite nanoplate networking ACS* Applied Materials and Interfaces, 5, 4712-4724

14. S. Maiti, N. K. Shrivastava, S. Suin, B. B. Khatua (2013)*A strategy for achieving low percolation and high electrical conductivity in melt-blended polycarbonate (PC)/multiwall carbon nanotube (MWCNT) nanocomposites: Electrical and thermo-mechanical properties* ,Express Polymer Letters, 7, 505-518.

15. Subas Muduli, Wonjoo Lee, Vivek Dhas, Sarfraj Mujawar, Megha Dubey, K. Vijayamohanan, Sung-Hwan Han, andSatishchandra Ogale (2009) *Enhanced Conversion Efficiency in Dye-Sensitized Solar Cells Based on Hydrothermally Synthesized TiO2−MWCNT Nanocomposites* , ACS Applied Materials & Interfaces , vol.9, 2030-2035

16. The Agency for Science, Technology and Research (A*STAR). *"Dye-sensitized solar cells that use carbon nanotube thin films as transparent electrodes offer significant cost savings."* ScienceDaily, 14 March 2012.

17. Shaker Ebrahim, Moataz Soliman, M. Anas, Mostafa Hafez, and Tarek M. Abdel-Fattah, (2013) *Dye-Sensitized Solar Cell Based on Polyaniline/Multiwalled Carbon Nanotubes Counter Electrode,* International Journal of Photoenergy, vol. 2013, Article ID 906820, 6 pages.